

CITY OF KNOXVILLE

Description

The purpose of this stormwater treatment BMP is to give a basic example of how to use the HEC-1 and HEC-HMS hydrograph programs in detention basin routing and design. The potential user of this BMP is expected to be thoroughly familiar with the TR-55 publication “Urban Hydrology for Small Watersheds” (reference 175) and also the theory and practical application of detention routing. The detention example for this BMP is the same one as used in ST-11 (Detention Example for Spreadsheet).

Approach

A brief description of detention requirements and NRCS methods are given in ST-10, Detention Computations. All hydrologic and hydraulic computations for stormwater detention facilities must be prepared and stamped by a registered engineer (licensed in the state of Tennessee) who is proficient in this field. Plans must show sufficient information to allow the builder to construct the detention structure correctly, and to verify that the detention facility operates as required.

In Section 22.5-33 of the Knoxville Stormwater and Street Ordinance, hydrologic and hydraulic computations are required to be in accordance with National Resources Conservation Service (NRCS) methods. The NRCS Unit Hydrograph shall be used with average antecedent moisture conditions (AMC II) and Type II rainfall distribution, as specified by Technical Release 55 (TR-55) publication from June 1986. The TR-55 publication (“Urban Hydrology for Small Watersheds”, reference 175) can be downloaded at:

<http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html>

NRCS Computational Software

A brief description of common hydrograph and detention routing software is given in ST-10, Detention Computations. This BMP represents one option available to the stormwater designer. Both HEC-1 and HEC-HMS are freely available software programs that can be downloaded from the U.S. Army Corps of Engineers website. These programs can generate hydrographs using several methods and also perform detention storage routing. The program user generates the elevation-discharge-volume (E-Q-V) curves by manually computing and analyzing each type of outlet device (by hand or with a spreadsheet) separately prior to combining the results as input data for the hydrograph routing program.

Software computations submitted for review to the City of Knoxville must include all of the necessary input data to reproduce the detention design, including details as needed to illustrate the outlet structure. Computations should be organized and neatly printed on standard 8.5” x 11” paper so that the results are easily referenced and located. The Knoxville Engineering Department may require verification of software programs that are unproven or not well-known in the Knoxville area.

**Overview of
HEC-1
Software*****Introduction***

HEC-1 is a commonly-used hydrograph program originally developed by the U.S. Army Corps of Engineers (USACE) over 30 years ago, and adapted to personal computers in the mid-1980s. The HEC-1 program and the associated HEC-1 user's manual can be downloaded from the USACE website at:

<http://www.hec.usace.army.mil/software/legacysoftware/hec1/hec1.htm>

HEC-1 is a DOS-based program for which the user prepares an input data file prior to running the program. Each line of the HEC-1 input file is called a "card" (from days when computers used punched cards). See the example input file on page ST-12-8. The first two letters of each line (columns 1-2) designate the type of data shown on that line. The example input file on page ST-12-6 uses the following 16 types of cards:

HEC-1
input
"cards"

ID = project identification, * = comments, IT = time specification
 IN = input data interval, IO = output control, KK = location identifier,
 BA = basin area, PB = basin total precipitation,
 PC = cumulative precipitation, RS = storage routing, LS = loss rate,
 UD = unit dimensionless hydrograph, SQ = discharge data,
 SV = storage volume data, SE = elevation data, ZZ = end of run

Appendix A of the *HEC-1 User's Manual* provides a complete description for the data fields. It is recommended that the HEC-1 user should print the input card description for each type of input card used. Each line contains up to 10 data fields with a maximum line length of 80 spaces or columns. The data fields are in a "fixed-format" unless otherwise specified by a *FREE card. The data fields each contain 8 spaces, except for the first data field which only has 6 spaces (columns 3-8). Numbers should be right-justified within each 8-space field and/or contain a decimal point.

The NRCS Type II rainfall distribution is entered on PC or PI cards; the example on page ST-12-8 is shown using cumulative rainfall fractions (PC cards) at intervals of 0.1 hours. Do not use PH cards to specify the intensity-duration-frequency curve, as this rainfall pattern does not match the NRCS Type II rainfall distribution.

Postdeveloped watershed input parameters (area, curve number, time of concentration) are entered on the BA, LS and UD cards. The basin area is entered as square miles on the first field of the BA card. The curve number is entered on the second field of LS card. Instead of the time of concentration, the lag time (in hours) is entered on the first field of the UD card, with the lag time equal to 2/3 of Tc.

The overall elevation-discharge-volume (E-Q-V) relationship is entered on matching fields of the cards labeled SE, SQ, and SV. The units for the E-Q-V curve are: feet elevation (SE), cubic feet per second (SQ), and acre-feet (SV). The following pages show an example of HEC-1 input file (for iteration #1 of the detention basin design *) and HEC-1 output file (for iteration #2 of the detention basin design **):

Worksheet #2
from ST-11 is
highly
recommended as
a starting point
for storage
volume estimates

Pages	Contents of HEC-1 file	File name
ST-12-8	* Initial detention estimate	HEC1-ex1.dat
ST-12-9 to ST-12-11	** Final detention computation output	HEC1-ex2.out

* Initial detention estimate corresponds to the example spreadsheet in ST-11.

** Final detention computation using the revised outlet configuration in ST-11.

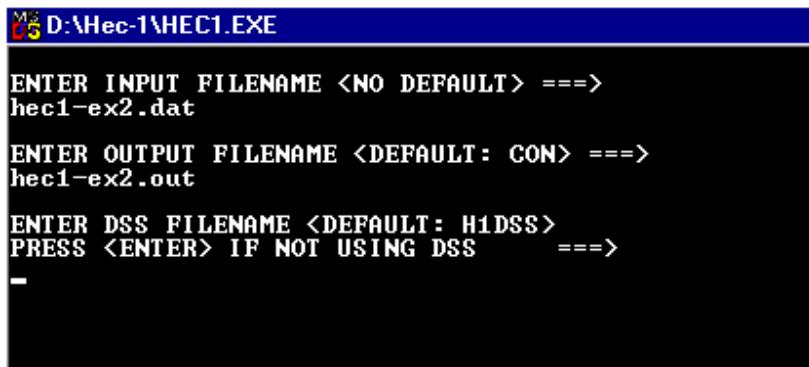
To improve the output precision of a HEC-1 run by a decimal point, perform these simple modifications:

- Multiply the basin area (BA card) by a factor of 10.
- Multiply either the pond areas or pond volumes (SA or SV cards) by a factor of 10.
- Multiply the pond outflows (SQ cards) by a factor of 10.

The example HEC-1 input file on page ST-12-8 includes the three modifications listed above (shown in bold print), using SV cards rather than SA cards. After running the HEC-1 file, the peak inflow and outflow values should be divided by 10 to determine the actual output values.

Hints for Using HEC-1 Example File

- After downloading and installing the HEC-1 program, it will run by clicking on the file HEC-1.EXE. As part of the HEC-1 program, a screen will pop up to ask for the input filename, the output filename, and an optional DSS filename (which is not needed). The input file needs to be in the same subdirectory as the HEC-1 program.



- The input data files for the initial design configuration (hec1-ex1.dat) and for the final outlet structure configuration (hec1-ex2.dat) are included in this BMP. The input data file can be easily edited using any type of ASCII text editor (such as Notepad). Align input data into the correct columns.
- The following cards each only need one value changed: BA, PB, LS, UD, RS. BA is the basin area in square miles, PB is the 24-hour rainfall in inches, LS is the postdeveloped curve number, UD is the time of concentration multiplied by 0.67, and RS is the starting water surface elevation of the analysis.
- The following cards need to be recomputed and revised whenever the detention basin volumes and/or outlet structure configuration are changed: SE, SQ, SV. A new E-Q-V curve can be computed by hand or by spreadsheet. Provide a sufficient number of values to accurately reflect the storage and discharge curves.
- The HEC-1 output data is formatted by the program for the wide green computer paper commonly used 30 years ago. To print onto 8.5" x 11" paper, shrink all of the output text to Courier New, font size 8, with 0.25" margins all around the page. Or print the results using paper with a landscape orientation.

ACTIVITY: Detention Example for HEC-1 & HEC-HMS	ST – 12
Overview of HEC-HMS Software <div style="border: 1px dashed black; padding: 5px; margin-top: 10px;"> HEC-HMS components </div>	<p><i>Introduction</i></p> <p>The HEC-HMS is a windows-based hydrograph program developed by the U.S. Army Corps of Engineers (USACE) to succeed HEC-1. The HEC-HMS software program and associated manuals can be downloaded from the USACE website at:</p> <p style="text-align: center;">http://www.hec.usace.army.mil/software/software.html</p> <p>Within the HEC-HMS program, the user creates three different types of components for each modeling run:</p> <ul style="list-style-type: none"> • Basin: size, precipitation loss functions, routing parameters, routing lengths and channels, baseflow, reservoirs. • Meteorological: precipitation gages, rainfall distributions, storm events. • Control: duration of analysis, time intervals, computational increment. <p>Different basin configurations and outlet structures can be tested by mixing and matching different components for a modeling run. After each modeling run, the routing results can be displayed by selecting each element from the basin schematic and choosing “View Results” from the menu. Graphical output and/or a global summary sheet can also be viewed. The HEC-HMS program can import HEC-1 input files, which can be helpful in preparing reports and graphs.</p> <p>The current version of HEC-HMS will only allow the user to directly input one orifice and one weir. For structures with more than one orifice, the user will have to compute the elevation-storage-discharge data separately (by hand or by spreadsheet) prior to entering the input data.</p> <p>The HEC-HMS data interface can be confusing. For instance, sometimes it is not obvious how to edit existing data files for the various components. For most screens, select the file with the cursor and then choose “Edit” from the pulldown menu.</p> <p>The HEC-HMS program is much more complicated than the HEC-1 program and will require a longer learning curve to use effectively. For most engineers, it will take some patience to learn how to use the HEC-HMS model. Read and review the available training documents (Users Manual, Technical Reference Manual) while practicing with the data sets provided by the U.S. Army Corps of Engineers.</p> <p>The NRCS Type II rainfall distribution can be typed into the precipitation gage data fields once, and then used over and over again for different projects by transferring gage data into new project files as needed. The rainfall distribution can be adjusted on each model run by choosing “Run Options” and then selecting a precipitation ratio.</p> <p>Other Hints for Using HEC-HMS Software</p> <ul style="list-style-type: none"> • The program user must save each component as it is being edited, and also must save the project file prior to exiting the HEC-HMS program. • The component with meteorological data, once it has been edited correctly, can be used and reused for all project files. The total rainfall amount can be adjusted on each model run by selecting “Run Options” from the Run Manager screen. • Each iteration (predeveloped & postdeveloped) can be run within the same basin model (shown on page ST-12-12) by placing the design elements in parallel alignment, reducing the number of basin files and components needed.

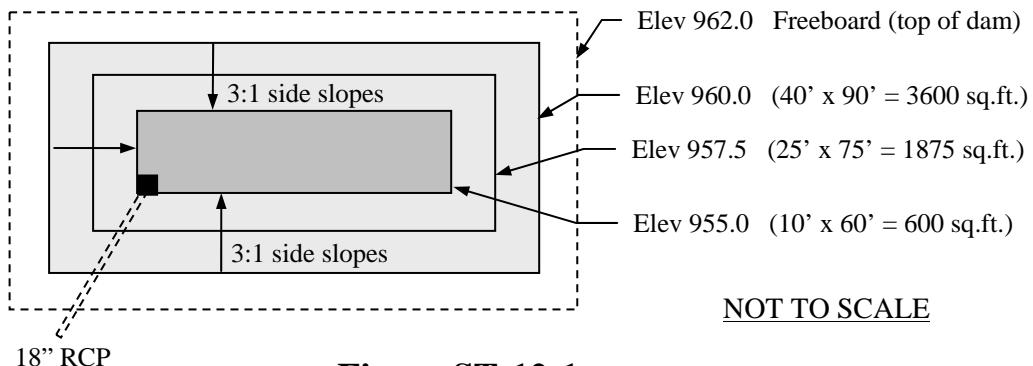
Detention Example

Figure ST-12-1
Example Detention Basin Geometry

Input Data Needed

The initial volume estimate was made using Worksheet #2 (page ST-11-11), which is based on NRCS methods outlined in the TR-55 publication. To summarize the watershed parameters from ST-11:

Predeveloped CN = 75

Predeveloped Tc = 0.4 hours

Predeveloped area = 1.5 acres

Postdeveloped CN = 90

Postdeveloped Tc = 0.1 hours

Postdeveloped area = 1.5 acres

Volumes are computed from a rectangular detention basin with 3:1 slopes:

10' x 60' at elevation 955

First flush volume = 4500 cubic feet

25' x 75' at elevation 957.5

(from elevation 958.20 and below)

40' x 90' at elevation 960

52' x 102' at elevation 962

The initial outlet structure configuration was selected as a square concrete riser with four circular orifices to limit postdevelopment flow rates to predevelopment flow rates:

- 4" orifice at invert 955.00
- 8" orifice at invert 957.85
- 6" orifice at invert 958.40
- 4" orifice at invert 959.20
- top of square concrete riser at 959.90 (total weir length of 8')

This iteration was computed in the HEC-1 input data file on page ST-12-6, and similar data was used within the HEC-HMS program. However, this outlet structure configuration did not account for the first flush volume to be detained for a minimum of 24 hours, so a second iteration was required. The bottommost orifice is sized as 1.25" diameter (page ST-10-9) to release the first flush volume (4500 cubic feet at the required flow rate). A second outlet structure configuration (determined by trial and error) is:

- 1.25" orifice at invert 955.00
- 8" orifice at invert 958.20
- 6" orifice at invert 958.50
- 4" orifice at invert 959.20
- top of square concrete riser at 960.65 (total weir length of 8')

Initial outlet structure configuration

Final outlet structure configuration

The second iteration was computed in the HEC-1 output file shown on pages ST-12-9 through ST-12-11. Both HEC-1 and HEC-HMS will require the user to first compute the overall elevation-discharge-volume (E-Q-V) curve. The E-Q-V curve for this example was taken from spreadsheets shown on pages ST-11-13 to ST-11-16 in the previous BMP.

After the stormwater detention computations are completed, an additional 15% storage volume is provided. Multiply the 100-year peak flow storage volume by 115% to determine an elevation adjustment value. Raise the top of the concrete riser (or other principal outlet control) by this value to provide 15% additional storage volume. An example of this computation is shown on page ST-10-8.

**HEC-1
Results**
Predevelopment Flows (HEC-1 Version 4.1, June 1998)

HEC-1 input file without detention for: A = 1.5 acres CN = 75 Tc = 0.4 hours

<i>Return period</i>	<i>Peak flow</i>	<i>Time of peak inflow</i>
1-year	0.8 cfs	11.93 hours
2-year	1.6 cfs	" "
5-year	2.4 cfs	" "
10-year	3.2 cfs	" "
25-year	4.0 cfs	" "
100-year	5.2 cfs	" "

Iteration #1: HEC-1 Results (Version 4.1, June 1998)

(Results from the HEC-1 input data file on page ST-12-8.)

<i>Return period</i>	<i>Peak inflow</i>	<i>Peak outflow</i>	<i>Target</i>	<i>Peak WSE</i>	<i>Time of peak outflow</i>
1-year	3.3 cfs	0.6 cfs	0.8 cfs ✓	957.53	12.20 hours
2-year	4.9 cfs	1.2 cfs	1.6 cfs ✓	958.24	12.17 "
5-year	6.4 cfs	2.3 cfs	2.4 cfs ✓	958.73	12.10 "
10-year	7.8 cfs	3.1 cfs	3.2 cfs ✓	959.11	12.10 "
25-year	9.2 cfs	3.8 cfs	4.0 cfs ✓	959.47	12.10 "
100-year	11.1 cfs	5.1 cfs	5.2 cfs ✓	959.90	12.10 "

Iteration #2: HEC-1 Results (Version 4.1, June 1998)

(Results from the HEC-1 output data file on pages ST-12-9 through ST-12-11.)

<i>Return period</i>	<i>Peak inflow</i>	<i>Peak outflow</i>	<i>Target</i>	<i>Peak WSE</i>	<i>Time of peak outflow</i>
1-year	3.3 cfs	0.2 cfs	0.8 cfs ✓	958.30	12.97 hours
2-year	4.9 cfs	1.2 cfs	1.6 cfs ✓	958.81	12.17 "
5-year	6.4 cfs	2.3 cfs	2.4 cfs ✓	959.31	12.10 "
10-year	7.8 cfs	3.1 cfs	3.2 cfs ✓	959.72	12.10 "
25-year	9.2 cfs	3.7 cfs	4.0 cfs ✓	960.11	12.10 "
100-year	11.1 cfs	5.4 cfs	5.2 cfs ✓	960.58	12.10 "

**HEC-HMS
Results**
Predevelopment Flows (HEC-HMS Version 2.2.1, October 2002)

HEC-HMS input file without detention for: A = 1.5 acres CN = 75 Tc = 0.4 hours

<i>Return period</i>	<i>Peak flow</i>	<i>Time of peak inflow</i>
1-year	0.83 cfs	11:58 hours
2-year	1.60 cfs	" "
5-year	2.46 cfs	" "
10-year	3.27 cfs	" "
25-year	4.10 cfs	" "
100-year	5.34 cfs	" "

Iteration #1: HEC-HMS Results (Version 2.2.1, October 2002)

<i>Return period</i>	<i>Peak inflow</i>	<i>Peak outflow</i>	<i>Target</i>	<i>Peak WSE</i>	<i>Time of peak outflow</i>
1-year	3.7 cfs	0.7 cfs	0.8 cfs ✓	957.68	12:10 hours
2-year	5.3 cfs	1.4 cfs	1.6 cfs ✓	958.34	12:08 "
5-year	6.9 cfs	2.5 cfs	2.5 cfs ✓	958.82	12:06 "
10-year	8.3 cfs	3.3 cfs	3.3 cfs ✓	959.19	12:06 "
25-year	9.7 cfs	4.0 cfs	4.1 cfs ✓	959.54	12:06 "
100-year	11.6 cfs	5.3 cfs	5.3 cfs ✓	959.96	12:06 "

Iteration #2: HEC-HMS Results (Version 2.2.1, October 2002)

<i>Return period</i>	<i>Peak inflow</i>	<i>Peak outflow</i>	<i>Target</i>	<i>Peak WSE</i>	<i>Time of peak</i>
1-year	3.7 cfs	0.3 cfs	0.8 cfs ✓	958.48	12:36 hours
2-year	5.3 cfs	1.6 cfs	1.6 cfs ✓	958.97	12:08 "
5-year	6.9 cfs	2.6 cfs	2.5 cfs ✓	959.47	12:06 "
10-year	8.3 cfs	3.3 cfs	3.3 cfs ✓	959.87	12:06 "
25-year	9.7 cfs	3.8 cfs	4.1 cfs ✓	960.24	12:06 "
100-year	11.6 cfs	6.3 cfs	5.3 cfs X	960.64	12:04 "

(Using a HEC-HMS project file similar to input file on page ST-12-8, but with an embedded Type II NRCS rainfall.)

By adding extra E-Q-V points at elevations 960.60, 960.70 and 960.80, the detention routing computations for the 100-year storm (for iteration #2) become more accurate:

100-year	11.6 cfs	5.5 cfs	5.3 cfs ✓	960.68	12:04 hours
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Conclusions

The example software programs used in this BMP (HEC-1 and HEC-HMS hydrograph routing) are able to generate inflow hydrographs and route them with a designed detention basin. Many commercially available programs can also accomplish these same tasks. Detention routing is necessary to verify that design estimates are adequate, particularly since the initial volume estimate method within the TR-55 document does not take into account the first flush volume requirements. Available detention space and configuration must be included into a project site very early in the design process.

Comparison of HEC-1 and HEC-HMS Programs

HEC-HMS has a few advantages over HEC-1 for detention routing analysis:

- The NRCS Type II storm can be easily selected as a menu option, instead of requiring to be input as a rainfall distribution with PC or PI cards.
- Basin areas can be entered with more precision; therefore, the user does not have to use the “multiply & divide by 10” procedure as per HEC-1 in order to add a decimal point to the final answers.
- U.S. Army Corps of Engineers is making adjustments/improvements to the HEC-HMS program each year. Therefore, HEC-HMS will be state-of-the-art for many years, while HEC-1 is no longer actively supported. Printing and checking graphical displays is easier to accomplish using HEC-HMS.

The advantages of HEC-1 include:

- The HEC-1 input data file (and/or output file) is easy to edit and contains all input information in one location. A single data file is easier to archive, share and print when compared to the multiple files used by HEC-HMS.
- HEC-1 is not as complicated as HEC-HMS and is easier for occasional users to learn and master.

References

153, 154, 158, 175, 180, 181, 186, 187, 200 (see BMP Manual Chapter 10 for list)
Knoxville Stormwater and Street Ordinance

ACTIVITY: Detention Example for HEC-1 & HEC-HMS

ST - 12

ID HEC-1 run for BMP Manual --- Initial volume estimate with the
 ID ST-12, Detention Examples initial outlet structure configuration.
 ID 10-YEAR 24-HOUR STORM
 *
 * This example problem has 1.5 acres, CN = 90, Tc = 0.1 hour.
 * The basin area (**BA**), pond volumes (**SV**) and pond outflows (**SQ**) are
 * multiplied by a factor of 10 to increase the precision of analysis.
 * In other words, the basin area is input as 0.02344 square miles (15 acres).
 * Detention basin is initially sized with spreadsheet ST-11 (Worksheet #2).
 * City of Knoxville - Engineering Department - Ken Oliver
 * May 1, 2003
 * File: Hecl-ex1.dat
 *
 IT 2 01MAY03 0000 1500 2000
 IN 6
 IO 5 0
 *
 KK AREA1 Runoff into detention basin
BA.02344 * Basin area must be entered as square miles.
 PB 4.8 * Total precipitation must be entered as inches.
 PC 0.000 0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008 0.009
 PC 0.010 0.012 0.013 0.014 0.015 0.016 0.017 0.018 0.020 0.021
 PC 0.022 0.023 0.024 0.026 0.027 0.028 0.029 0.031 0.032 0.033
 PC 0.034 0.036 0.037 0.038 0.040 0.041 0.042 0.044 0.045 0.047
 PC 0.048 0.049 0.051 0.052 0.054 0.055 0.057 0.058 0.060 0.061
 PC 0.063 0.065 0.066 0.068 0.070 0.071 0.073 0.075 0.076 0.078
 PC 0.080 0.082 0.084 0.085 0.087 0.089 0.091 0.093 0.095 0.097
 PC 0.099 0.101 0.103 0.105 0.107 0.109 0.111 0.113 0.116 0.118
 PC 0.120 0.122 0.125 0.127 0.130 0.132 0.135 0.138 0.141 0.144
 PC 0.147 0.150 0.153 0.157 0.160 0.163 0.166 0.170 0.173 0.177
 PC 0.181 0.185 0.189 0.194 0.199 0.204 0.209 0.215 0.221 0.228
 PC 0.235 0.243 0.251 0.261 0.271 0.283 0.307 0.354 0.431 0.568
 PC 0.663 0.682 0.699 0.713 0.725 0.735 0.743 0.751 0.759 0.766
 PC 0.772 0.778 0.784 0.789 0.794 0.799 0.804 0.808 0.812 0.816
 PC 0.820 0.824 0.827 0.831 0.834 0.838 0.841 0.844 0.847 0.850
 PC 0.854 0.856 0.859 0.862 0.865 0.868 0.870 0.873 0.875 0.878
 PC 0.880 0.882 0.885 0.887 0.889 0.891 0.893 0.895 0.898 0.900
 PC 0.902 0.904 0.906 0.908 0.910 0.912 0.914 0.915 0.917 0.919
 PC 0.921 0.923 0.925 0.926 0.928 0.930 0.931 0.933 0.935 0.936
 PC 0.938 0.939 0.941 0.942 0.944 0.945 0.947 0.948 0.949 0.951
 PC 0.952 0.953 0.955 0.956 0.957 0.958 0.960 0.961 0.962 0.964
 PC 0.965 0.966 0.967 0.968 0.970 0.971 0.972 0.973 0.975 0.976
 PC 0.977 0.978 0.979 0.981 0.982 0.983 0.984 0.985 0.986 0.988
 PC 0.989 0.990 0.991 0.992 0.993 0.994 0.996 0.997 0.998 0.999
 PC 1.000
 LS 0 90 * This is the postdeveloped curve number (CN=90).
 UD .067 * This is the SCS lag time in hours (equal to 2/3 of Tc).
 *
 KK PONDA Route the hydrograph from Area 1 through Pond A
 RS 1 ELEV 955.0 0
 SV 0 0.0807 0.1876 0.3230 0.4886 0.6869 0.9196 1.1887 1.4964 1.8448
 SV2.2358 2.6717 3.1543 3.6859 4.2685
 SQ 0.00 2.4 3.8 4.9 5.7 6.4 7.7 17.2 29.0 38.2
 SQ 53.8 164.2 198.0 208.0 218.0
 SE 955.0 955.5 956.0 956.5 957.0 957.5 958.0 958.5 959.0 959.5
 SE 960.0 960.5 961.0 961.5 962.0
 ZZ

```
*****
*          *
*   FLOOD HYDROGRAPH PACKAGE (HEC-1)   *
*   U.S. ARMY CORPS OF ENGINEERS        *
*           JUN 1998                   *
*   HYDROLOGIC ENGINEERING CENTER      *
*           VERSION 4.1                 *
*           609 SECOND STREET          *
*           *
*           DAVIS, CALIFORNIA 95616    *
*   RUN DATE    1MAY03 TIME 11:20:31   *
*           (916) 756-1104             *
*           *
*****
```

X	X	XXXXXXX	XXXXX	X
X	X	X	X	XX
X	X	X	X	X
XXXXXXX	XXXX	X	XXXXX	X
X	X	X	X	X
X	X	X	X	X
X	X	XXXXXXX	XXXXX	XXX

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73),
HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED
WITH THE 1973-STYLE INPUT STRUCTURE.

THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED
28 SEP 81. THIS IS THE FORTRAN77 VERSION

NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION,
DSS:WRITE STAGE FREQUENCY
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL
LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

HEC-1 INPUT

LINE

ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

1 ID HEC-1 run for BMP Manual --- Detention rating computations with the
2 ID ST-12, Detention Examples final outlet structure configuration
3 ID 10-YEAR 24-HOUR STORM Only the SQ cards have been changed.

* This example problem has 1.5 acres, CN = 90, Tc = 0.1 hour.
* The basin (**BA**), pond volumes (**SV**) and pond outflows (**SQ**) are
* multiplied by a factor of 10 to increase the precision of analysis.
* In other words, the basin area is input as 0.02344 square miles (15 acre

* Detention basin was initially sized using NRCS TR-55 methodology.
* City of Knoxville - Engineering Department - Ken Oliver
* May 1, 2003
* File: Hecl-ex2.dat

*DIAGRAM

4 IT 2 01MAY03 0000 1500 2000
5 IN 6
6 IO 5 0

```

*
*      1-year storm    2.5"
*      2-year storm    3.3"
*      5-year storm    4.1"
*     10-year storm   4.8"
*     25-year storm   5.5"
*     50-year storm   6.1"
*    100-year storm   6.5"
*
7  KK    AREA1      Runoff into detention basin
8  BA  .02344      (= 15.0 acres, which is ten times the actual area of 1.5 acres)
9  PB    4.8
10 PC  0.000  0.001  0.002  0.003  0.004  0.005  0.006  0.007  0.008  0.009
11 PC  0.010  0.012  0.013  0.014  0.015  0.016  0.017  0.018  0.020  0.021
12 PC  0.022  0.023  0.024  0.026  0.027  0.028  0.029  0.031  0.032  0.033
13 PC  0.034  0.036  0.037  0.038  0.040  0.041  0.042  0.044  0.045  0.047
14 PC  0.048  0.049  0.051  0.052  0.054  0.055  0.057  0.058  0.060  0.061
15 PC  0.063  0.065  0.066  0.068  0.070  0.071  0.073  0.075  0.076  0.078
16 PC  0.080  0.082  0.084  0.085  0.087  0.089  0.091  0.093  0.095  0.097
17 PC  0.099  0.101  0.103  0.105  0.107  0.109  0.111  0.113  0.116  0.118
18 PC  0.120  0.122  0.125  0.127  0.130  0.132  0.135  0.138  0.141  0.144
19 PC  0.147  0.150  0.153  0.157  0.160  0.163  0.166  0.170  0.173  0.177
20 PC  0.181  0.185  0.189  0.194  0.199  0.204  0.209  0.215  0.221  0.228
21 PC  0.235  0.243  0.251  0.261  0.271  0.283  0.307  0.354  0.431  0.568
22 PC  0.663  0.682  0.699  0.713  0.725  0.735  0.743  0.751  0.759  0.766
23 PC  0.772  0.778  0.784  0.789  0.794  0.799  0.804  0.808  0.812  0.816
24 PC  0.820  0.824  0.827  0.831  0.834  0.838  0.841  0.844  0.847  0.850
25 PC  0.854  0.856  0.859  0.862  0.865  0.868  0.870  0.873  0.875  0.878
26 PC  0.880  0.882  0.885  0.887  0.889  0.891  0.893  0.895  0.898  0.900
27 PC  0.902  0.904  0.906  0.908  0.910  0.912  0.914  0.915  0.917  0.919
28 PC  0.921  0.923  0.925  0.926  0.928  0.930  0.931  0.933  0.935  0.936
29 PC  0.938  0.939  0.941  0.942  0.944  0.945  0.947  0.948  0.949  0.951
30 PC  0.952  0.953  0.955  0.956  0.957  0.958  0.960  0.961  0.962  0.964
31 PC  0.965  0.966  0.967  0.968  0.970  0.971  0.972  0.973  0.975  0.976
32 PC  0.977  0.978  0.979  0.981  0.982  0.983  0.984  0.985  0.986  0.988
33 PC  0.989  0.990  0.991  0.992  0.993  0.994  0.996  0.997  0.998  0.999
34 PC  1.000
35 LS    0      90
36 UD  .067
*
37 KK  PONDA
38 KM          ROUTE HYDROGRAPH FROM AREA A THROUGH POND A
39 RS    1    ELEV  955.0      0
40 SV    0  0.0807  0.1876  0.3230  0.4886  0.6869  0.9196  1.1887  1.4964  1.8448
41 SV2.2358 2.6717  3.1543  3.6859  4.2685
42 SQ    0.0   0.3    0.4    0.5    0.6    0.6    0.7    3.0    17.0   27.0
43 SQ  35.2  41.5  119.4  208.0  218.0
44 SE  955.0  955.5  956.0  956.5  957.0  957.5  958.0  958.5  959.0  959.5
45 SE  960.0  960.5  961.0  961.5  962.0
46 ZZ

```

SCHEMATIC DIAGRAM OF STREAM NETWORK

INPUT
 LINE (V) ROUTING (--->) DIVERSION OR PUMP FLOW
 NO. (.) CONNECTOR (<---) RETURN OF DIVERTED OR PUMPED FLOW

7 AREAL

V
V
37 PONDA

(****) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
*****
*          *
*   FLOOD HYDROGRAPH PACKAGE (HEC-1)  *
*   U.S. ARMY CORPS OF ENGINEERS      *
*           JUN 1998                  *
*   HYDROLOGIC ENGINEERING CENTER    *
*           VERSION 4.1              *
*           609 SECOND STREET        *
*           *
*           DAVIS, CALIFORNIA 95616  *
*   RUN DATE     1MAY03 TIME 11:20:31  *
*           (916) 756-1104            *
*           *
*****
```

HEC-1 run for BMP Manual --- Detention rating computations with the
 ST-12, Detention Examples final outlet structure configuration
 10-YEAR 24-HOUR STORM Only the SQ cards have been changed.

6 IO OUTPUT CONTROL VARIABLES
 IPRNT 5 PRINT CONTROL
 IPLOT 0 PLOT CONTROL
 QSCAL 0. HYDROGRAPH PLOT SCALE

IT HYDROGRAPH TIME DATA
 NMIN 2 MINUTES IN COMPUTATION INTERVAL
 IDATE 1MAY 3 STARTING DATE
 ITIME 0000 STARTING TIME
 NQ 1500 NUMBER OF HYDROGRAPH ORDINATES
 NDDATE 3MAY 3 ENDING DATE
 NDTIME 0158 ENDING TIME
 ICENT 20 CENTURY MARK

COMPUTATION INTERVAL .03 HOURS
 TOTAL TIME BASE 49.97 HOURS

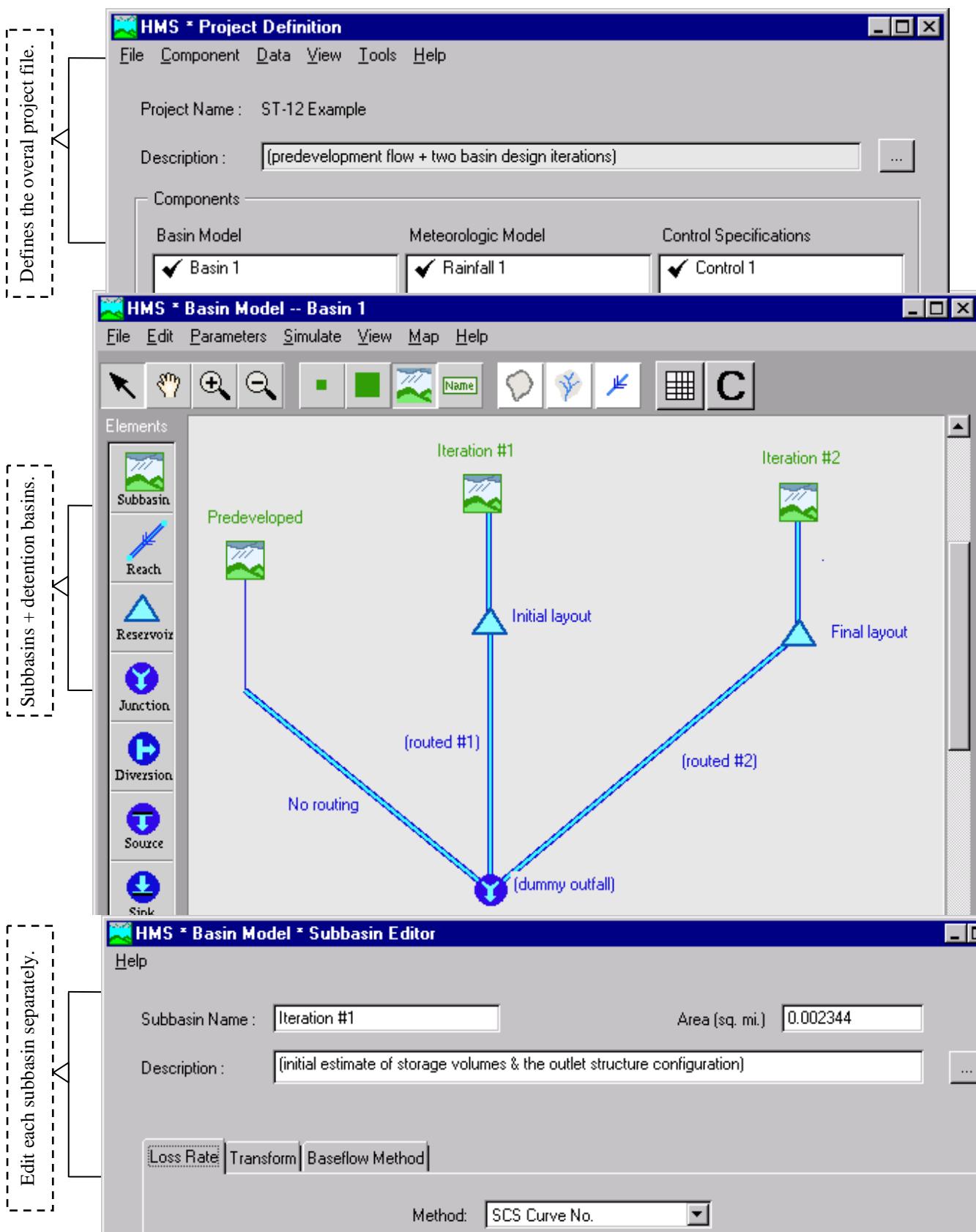
ENGLISH UNITS
 DRAINAGE AREA SQUARE MILES
 PRECIPITATION DEPTH INCHES
 LENGTH, ELEVATION FEET
 FLOW CUBIC FEET PER SECOND
 STORAGE VOLUME ACRE-FEET
 SURFACE AREA ACRES
 TEMPERATURE DEGREES FAHRENHEIT

RUNOFF SUMMARY
 FLOW IN CUBIC FEET PER SECOND
 TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW	FOR 6-HOUR	MAXIMUM PERIOD	BASIN AREA	MAX STAGE	TIME OF MAX STAGE
HYDROGRAPH AT ROUTED TO	AREA1 PONDA	78. 31.	11.93 12.10	7. 6.	2. 2.	1. 1.	.02 .02	959.72	12.10

*** NORMAL END OF HEC-1 ***

Portions of input data and output summary from HEC-HMS:



HMS * Basin Model * Reservoir Editor

Reservoir Name: Initial layout

Description:

Storage | Outlet | Spillway | Overflow | Dam Break

Method: Elevation-Storage-Outflow

Initial Elevation (ft) 955.0

Elevation (ft)	Storage (acre-feet)	Outflow (cfs)
955.0	0.00000	0.00
955.5	0.00807	0.24
956.0	0.01876	0.38
956.5	0.03230	0.49
957.0	0.04886	0.57
957.5	0.06869	0.64
958.0	0.09196	0.77
958.5	0.11887	1.72

HMS * Meteorologic Model

Meteorologic Model: Rainfall 1 Subbasin List

Precipitation | Evapotranspiration

Method: SCS Hypothetical Storm

Storm Selection: Type II

Storm Depth (in): 6.5

HMS * Control Specifications

Control Specs ID: Control 1

Starting Date: 01 May 2003 Starting Time: 00:00

Ending Date: 03 May 2003 Ending Time: 02:00

Time Interval: 2 Minutes

Defines the rainfall distribution.

Compute storage and outflow data at regular intervals for input.

Computational time interval.

